WHAT IS CLAIMED IS:

1. A digital watermark embedding apparatus comprising:

a first generation unit configured to generate a plurality of symbol sequences each of which includes a plurality of symbols including ranks, each of the ranks being uniquely numbered among each of the symbol sequences, each of the symbol sequences uniquely corresponding to each of a plurality of identification information items to be embedded as digital watermark information into each of copies of digital contents;

a second generation unit configured to generate a plurality of to-be-embedded codes corresponding to each of the symbols in each of the symbol sequences; and

an embedding unit configured to embed the to-be-embedded codes in each of the copies.

2. The digital watermark embedding apparatus according to claim 1, wherein the second generation unit generates the to-be-embedded codes in a random number sequence such that the to-be-embedded codes corresponding to symbols including a same rank in the symbol sequences include one of no cross-correlation and a very low cross-correlation.

3. The digital watermark embedding apparatus according to claim 2, wherein the second generation unit generates the to-be-embedded codes in a random number sequence such that the to-be-embedded codes

corresponding to symbols differing in rank in the symbol sequences include one of no cross-correlation and a very low cross-correlation.

4. The digital watermark embedding apparatus according to claim 1, wherein:

the identification information items include a plurality of integers;

a plurality of particular integers are preset for each of the ranks of each of the symbol sequences; and

the first generation unit divides each of the identification information items by each of the particular integers to obtain a plurality of residuals, arranges, in accordance with the ranks, the residuals corresponding to each of the ranks, and outputs the residuals arranged as an output symbol sequence.

5. The digital watermark embedding apparatus according to claim 4, wherein the particular integers are relatively prime to each other.

6. The digital watermark embedding apparatus according to claim 1, wherein:

the identification information items include a plurality of integers;

a plurality of particular integers are preset for each of the ranks of each of the symbol sequences; and

the first generation unit divides each of the identification information items by each of the particular integers to obtain a plurality of residuals,

converts, into a plurality of unique information items, the residuals corresponding to each of the ranks, arranges the unique information items in accordance with the ranks, and outputs the unique information items arranged as an output symbol sequence.

7. The digital watermark embedding apparatus according to claim 6, wherein the particular integers are relatively prime to each other.

8. The digital watermark embedding apparatus according to claim 1, wherein a range of an identification information amount which can be embedded as watermark information into the copies is set narrower than a range of an identification information amount to which the symbol sequence is assigned.

9. The digital watermark embedding apparatus according to claim 1, wherein the identification information items include unique information assigned to users who provide the copies.

10. A digital watermark analysis apparatus for specifying at least one of a plurality of identification information items embedded as a plurality of watermark information items in a plurality of legal copies of digital contents used for collusive attacks, from a plurality of illegal copies of the digital contents obtained by collusive attacks made against the legal copies, the digital watermark analysis apparatus comprising:

an extraction unit configured to extract a plurality of embedded codes including ranks from the illegal copies, each of the ranks being uniquely numbered among each of the symbol sequences;

an acquisition unit configured to acquire a plurality of symbols corresponding to the embedded codes and arrange the symbols in accordance with the ranks of the embedded codes, and acquire a first symbol sequence of symbol sequences each of which includes a plurality of the symbols based on the symbols; and

a specifying unit configured to specify at least one of the identification information items embedded in the legal copies, based on the first symbol sequence and second symbol sequences uniquely assigned to the identification information items.

11. The digital watermark analysis apparatus according to claim 10, wherein:

the specifying unit specifies at least one of the identification information items based on the second symbol sequences each of which include a plurality of symbols including the ranks; and

the acquisition unit acquires a plurality of the symbols including the ranks, the symbols corresponding to the embedded codes, the embedded codes being embedded in the legal copies.

12. The digital watermark analysis apparatus according to claim 10, wherein the extraction unit

extracts, in units of the ranks, one of the embedded codes corresponding to the symbols, the one of the embedded codes being estimated to be most frequently used in the collusive attacks.

13. The digital watermark analysis apparatus according to claim 10, wherein:

the extraction unit extracts several of the embedded codes which are generated in a random number sequence such that the embedded codes corresponding to the symbols including a same rank in the symbol sequences include one of no cross-correlation and a very low cross-correlation; and

the extraction unit obtains, in units of the ranks, cross-correlation between embedded codes corresponding to the symbols contained in the first symbol sequence, and obtains one of the embedded codes which includes a maximum cross-correlation.

14. The digital watermark analysis apparatus according to claim 13, wherein the extraction unit extracts several of the embedded codes which are generated in a random number sequence such that the embedded codes corresponding to the symbols differing in each of the ranks in the symbol sequences include one of no cross-correlation and a very low cross-correlation.

15. The digital watermark analysis apparatus according to claim 10, wherein the acquisition unit

compares the second symbol sequences with third symbol sequences extracted from the illegal copies, and specifies at least one of the identification information items embedded in the legal copies based on comparison results of the acquisition unit.

16. The digital watermark analysis apparatus according to claim 15, wherein the acquisition unit compares, in units of the ranks, the second symbol sequences with the third symbol sequences, and if the third symbol sequences are identical at the ranks greater than a preset number of the ranks, the identification information items are determined to be those embedded in the legal copies.

17. The digital watermark analysis apparatus according to claim 16, wherein

if the identification information items are a plurality of integers, a plurality of particular integers N(i) ($\underline{i}$: integer, $N(1) \leqq N(2) \leqq \ldots \leqq N(M)$) are preset for each of the ranks $\underline{i}$ of each of the second symbol sequences, and the extraction unit selects, from a range of $0 \sim N(i)-1$, a symbol S(i) corresponding to each of the ranks $\underline{i}$ of the second symbol sequences, and arranges the symbol S(i), into a to-be-generated symbol sequence, in accordance with each of the ranks $\underline{i}$,

the preset number is $(k + 1)$,

where $\underline{k}$ is a value which makes a product of N(1), …, N(k) higher than a total number of the identification

information items, and $\underline{l}$ satisfies $[1-\Pi\ 1/N(i)]^S \geqq 1 - \varepsilon_2$ (a range of i that assumes Π is $i = 1 \sim l$ or $i = k + 1 \sim (k + l)$, $S = {}_MC_{k+1}$, and ε_2 $(0 < \varepsilon_2 < 1)$ represents a rate of error tracing at which erroneous identification information is specified as the identification information embedded in the legal copies).

18. The digital watermark analysis apparatus according to claim 16, wherein

if the identification information items are a plurality of integers, a plurality of particular integers N(i) ($\underline{i}$: integer, $q = N(1) = N(2) = \ldots = N(M)$) are preset for each of the ranks $\underline{i}$ of each of the second symbol sequences, and the extraction unit selects, from a range of $0 \sim N(i)-1$, a symbol S(i) corresponding to each of the ranks $\underline{i}$ of the second symbol sequences, and arranges the symbol S(i), into a to-be-generated symbol sequence, in accordance with each of the ranks $\underline{i}$,

the predetermined number is $(k + l)$,

where $\underline{k}$ is a value which makes a product of N(1), …, N(k) higher than a total number of the identification information items, and $\underline{l}$ satisfies $[1 - 1/q^l]^S \geqq 1 - \varepsilon$, where $S = {}_MC_{k+1}$, and ε $(0 < \varepsilon < 1)$ represents a rate of error tracing at which erroneous identification information is specified as the identification information embedded in the legal copies.

19. The digital watermark analysis apparatus according to claim 10, wherein a maximum number of the legal copies is set to a preset value, and the acquisition unit specifies at least one of collusion groups which form the symbol sequences extracted from the legal copies, and determines at least one of the identification information items embedded in the legal copies based on at least one collusion group, the collusion groups being each formed of a combination of identification information items assigned to a number of legal copies not larger than the maximum number of legal copies.

20. The digital watermark analysis apparatus according to claim 19, wherein if only one of the collusion groups is specified, the acquisition unit specifies all identification information items forming the one collusion group, as the identification information items embedded in the legal copies.

21. The digital watermark analysis apparatus according to claim 19, wherein if a plurality of groups not less than two collusion groups are specified, the acquisition unit specifies only common identification information of the collusion groups as identification information embedded in the legal copies.

22. The digital watermark analysis apparatus according to claim 10, wherein a range of an identification information amount which is embedded as

watermark information into the legal copies is set narrower than a range of an identification information amount to which the symbol sequences is assigned.

23. The digital watermark analysis apparatus according to claim 10, wherein the identification information items includes unique information assigned to users who provide the legal copies.

24. A digital watermark embedding method comprising:

generating a plurality of symbol sequences each of which includes a plurality of symbols including ranks, each of the ranks being uniquely numbered among each of the symbol sequences, each of the symbol sequences uniquely corresponding to each of a plurality of identification information items to be embedded as digital watermark information into each of copies of digital contents;

generating a plurality of to-be-embedded codes corresponding to each of the symbols in each of the symbol sequences; and

embedding the to-be-embedded codes in each of the copies.

25. A digital watermark analysis method of specifying at least one of a plurality of identification information items embedded as a plurality of watermark information items in a plurality of legal copies of digital contents used for collusive attacks,

from a plurality of illegal copies of the digital contents obtained by collusive attacks made against the legal copies, the digital watermark analysis method comprising:

extracting a plurality of embedded codes including ranks from the illegal copies, each of the ranks being uniquely numbered among each of the symbol sequences;

acquiring a plurality of symbols corresponding to the embedded codes and arranging the symbols in accordance with the ranks of the embedded codes, and acquiring a first symbol sequence of symbol sequences each of which includes a plurality of the symbols based on the symbols; and

specifying at least one of the identification information items embedded in the legal copies, based on the first symbol sequence and second symbol sequences uniquely assigned to the identification information items.

26. A program stored in a computer readable medium, comprising:

means for instructing a computer to generate a plurality of symbol sequences each of which includes a plurality of symbols including ranks, each of the ranks being uniquely numbered among each of the symbol sequences, each of the symbol sequences uniquely corresponding to each of a plurality of identification information items to be embedded as digital watermark

information into each of copies of digital contents;

means for instructing the computer to generate a plurality of to-be-embedded codes corresponding to each of the symbols in each of the symbol sequences; and

means for instructing the computer to embed the to-be-embedded codes in each of the copies.

27. A program stored in a computer readable medium which enables a computer to function as a digital watermark analysis apparatus for specifying at least one of a plurality of identification information items embedded as a plurality of watermark information items in a plurality of legal copies of digital contents used for collusive attacks, from a plurality of illegal copies of the digital contents obtained by collusive attacks made against the legal copies, the program comprising:

means for instructing the computer to extract a plurality of embedded codes including ranks from the illegal copies, each of the ranks being uniquely numbered among each of the symbol sequences;

means for instructing the computer to acquire a plurality of symbols corresponding to the embedded codes and arranging the symbols in accordance with the ranks of the embedded codes, and acquiring a first symbol sequence of symbol sequences each of which includes a plurality of the symbols based on the symbols; and

means for instructing the computer to specify at least one of the identification information items embedded in the legal copies, based on the first symbol sequence and second symbol sequences uniquely assigned to the identification information items.